The gorge into which the creek plunges below the western basin has a roughly basin-shaped appearance and may be a large cirque belonging to the valley-glacier stage now much dissected.

The probable history of the present drainage-scheme may be taken back to the pre-valley-glacier stage, when there may have been two parallel river-valleys rising west of Mt. Kosciusko and trending south into Cootapatamba valley—the ancestors of C_1 and C_2. During the valley-glacier stage both were gradually filled with the ice of

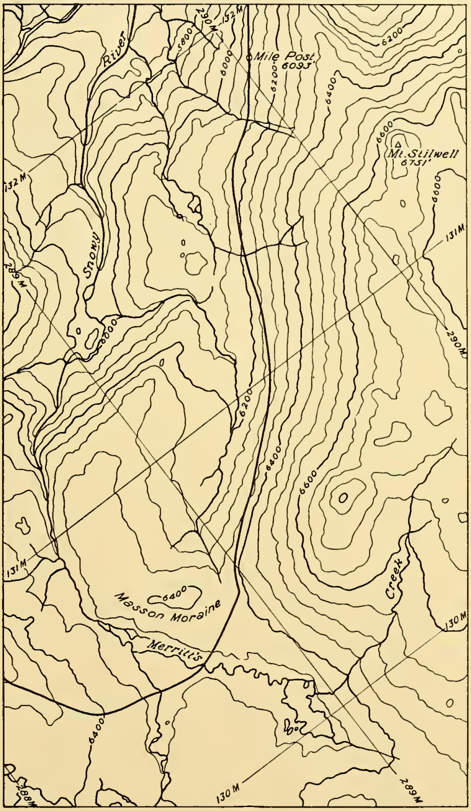

Fig. 2. A map of part of the Upper Snowy drainage system. The length of the side of a square on the grid represents one mile. North is towards the top left.

two glaciers, which eventually coalesced through the partial submergence of the ridge dividing them. At first both glaciers discharged into Cootapatamba valley, but later, through breaching of the ridge in two places, the better-nourished ice in the headward part of the eastern glacier was almost wholly diverted to join the western, which had its head in two shallow cirques. The ice accumulating near the head of this western valley spilled over a low part of its western wall into a large cirque at the head of a west-flowing tributary of the Lower Cootapatamba valley, and the path it took eventually became a principal outlet. Mild over-deepening gave rise to the elongated basin at the head of the creek and to that in the more western cirque.

When the ice finally melted the eastern meridional stream following the path of the glacier assumed its present course, determining factors being the deposition of moraine in the col just below its right-angled bend and in the larger col at the head of C_2. Seasonal deposition of clays occurred in the over-deepened basins, followed by the formation of bogs in them. These have been drained and their characters modified through the erosion of meandering channels.

Thus it would seem that beheading of the two pre-glacial streams C_1 and C_2 and the formation of the apparent water-gaps at A and B were due primarily to erosion by valley-glaciers.

Diversion in the Upper Snowy System.

The most southerly headwaters of the Snowy River rise in the acute angle formed by the junction of the Main Dividing Range and the Ramshead Range. There are three principal streams, each of which after descending from the higher ground meanders over an alluviated flat. The two more westerly streams join about 500 yards south of the Summit Road, and the most easterly—Merritt's Creek—flows north-west to join the main stream some 200 yards north of the road. The flats are strewn with moraine blocks and are to some extent boggy and have the appearance of drained lakes, though boring with a soil-auger revealed no sign of varved structure in the clays. The basins are bounded by ridges of solid granite, partly moraine-covered. Based on the Kangaroo Range and running a little north of west, the Masson Moraine* bounds Merritt's Creek on the north-east. Heading on the northern flank of this moraine is a creek which may be called Masson Creek; this flows north-east in a valley with wide flare, separated from the Snowy River by a ridge about 150 feet high. About a mile down its valley the creek turns sharply left, flows through a gap 100 feet high in the bounding ridge, and descends about 120 feet in 500 yards to join the Snowy (Fig. 2). At the bend a small collinear tributary comes in from the north rising in a col, and on the other side of this valley-divide rises another small creek which joins the Snowy a mile farther down, descending gently and then steeply through some 400 feet in 1,100 yards by a veritable hanging valley. Glacial evidences are present everywhere. The three headwater basins have obviously been scooped out by glaciers, and numbers of large erratics are strewn over their floors. Looking up Masson Creek one observes the Masson Moraine, with boulders up to 20 feet long, stretching like a great wall more than 100 feet high across its head and continuing west as a veneer on the solid granite of the ridge separating Masson Creek from the Snowy right over to the river itself. The valley floor and sides of Masson Creek are also strewn with moraine boulders, and at one point the deposits of a tiny drained lake dammed by a little recessional moraine are seen.

It appears that prior to the valley-glaciation the valleys of Merritt's Creek and Masson Creek were continuous across the site of the present Masson Moraine and joined the Snowy about a mile north of the present mouth of Masson Creek. Later the headwater tracts of the Snowy and Merritt's Creek were much modified by glacier-ice, which was continuous across them both. One glacier descended the present Snowy valley and another occupied the Merritt-Masson valley at a higher level. With increasing refrigeration the ice overtopped the dividing ridge in places and eventually overflowed through a gap in this ridge, which in time became deepened to form the chief outlet, the attenuated remainder continuing on in the original valley to join the Snowy glacier farther north. On the retreat of the glaciers the ice-gap became the outlet for the thaw-waters, and part of the northerly continuation of the Masson Creek valley became obsequent while the remainder flowed north to the Snowy by the thalweg of the original tributary glacier.

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* In what follows we assume that this moraine (first noted by Taylor *et al.* in 1925) is a true recessional or terminal moraine, as it appears to be, and not an accumulation of ground-moraine above a core of solid granite.

A subsequent halt by the retreating ice gave rise to the Masson Moraine, which stretched from the valley of Merritt's Creek across to that of the Snowy and formed a barrier that on the complete melting of the ice converted the headwater tracts into an expanse of lake-waters, by whose overflow it was eventually breached on its western side.

Thus the original Merritt-Masson Creek suffered diversion and mutilation at two points as the result of erosion and deposition by valley-glaciers.

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References

BROWNE, W. R., 1952.—Our Kosciusko Heritage. The David Memorial Lecture, 1952. Supplement to the *Australian Jour. Sci.*, 15, no. 3.

TAYLOR, G., BROWNE, W. R., and JARDINE, F., 1925.—The Kosciusko Plateau: A Topographic Reconnaissance. *Jour. Proc. Roy. Soc. N.S.W.*, 59: 200-205.

AN ESTIPULODIC FORM OF *CHARA AUSTRALIS* R. BR. (= *PROTOCHARA AUSTRALIS* WOMS. AND OPHEL).

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(Plates ix–x; six Text-figures.)

[Read 30th November, 1955.]

Synopsis.

Plants from New South Wales and Victoria intermediate in form between *Chara australis* and *Protochara australis* are described together with a report on chromosome number, culture methods and breeding experiments. In the taxonomic summary reasons are presented for combining *Protochara* with *Chara.*

In 1947, *Protochara* Woms. & Ophel, a new genus of the Characeae, was described from Australian material. This new genus was set up to include the two species *P. australis* Woms. & Ophel, and *P. inflata* (Filarszky & Allen, ex Fil.) Woms. & Ophel.

Protochara australis strongly resembles *Chara australis* R. Br. var. *australis* (= var. *nobilis* A. Br.) and seems to differ from the latter mainly in the usual absence of stipulodes and bract-cells. For various reasons, as given below, we find that *Protochara* cannot be retained as a distinct genus, and that *P. australis* and *P. inflata* should be transferred to the genus *Chara.*

HISTORY OF THE COLLECTIONS.

Several collections of the Characeae from Western Australia, South Australia, Victoria and New South Wales have been referred to the genus *Protochara.* The first of these, Burbidge, Sept., 1933, was referred (Filarszky, 1936) to the genus *Nitellopsis,* as *N. inflata* Fil. & Allen. Later, *N. inflata* was transferred (Womersley & Ophel, 1947) to the genus *Protochara.*

A second collection, Womersley A 5917 a, also from Western Australia, was referred by Womersley and Ophel (1947) to *Protochara* as *P. australis,* which was designated the type species of the genus. At the same time a collection of *P. australis* was made by G. G. Smith from the same locality. Subsequent attempts to collect material of *Protochara* in Western Australia have been unsuccessful, but recently an abundance of *P. inflata* has been found in South Australia.

Our own collections of *Protochara* have been made from one locality near Cooma, New South Wales (Hotchkiss 90, 91, and Macdonald 292, 293), and in one instance from the Brisbane Ranges, Victoria (Macdonald 320). Because of the absence of stipulodes and bract-cells, difficulty was found at first in identifying this material. The generic names *Tolypellopsis* and *Nitellopsis* were considered until finally *Protochara* was arrived at. Material was sent to H. B. S. Womersley, who kindly confirmed this latter identification. The habit of *Protochara australis* from Cooma, New South Wales, is shown in Plate ix, Figs. 1, 2.

ECOLOGY.

A study of what is known of the collection localities indicates that there may be some correlation between the type of habitat and the entities assigned to the genus *Protochara.* The common features in the various localities include shallow water and an intermittent water-supply in which the period of water may be of much shorter duration than the dry period, and probably prolonged periods of sunlight of high intensity. Table 1 summarizes observations made at the site at Cooma, New South Wales.

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TABLE 1.
Collection Data at Cooma, N.S.W.

Date.	Depth.	Notes.
December, 1952	90 cm.	Characeae not observed.
February, 1953	60 cm.	Characeae fruiting, collections made.
May, 1953	Nearly dry.	Characeae dying; collection of viable spores from the wet bottom mud.
January, 1954	Entirely dry.	Ground cracked open; collection of viable spores from dry bottom mud.
August, 1954	Entirely dry.	
January, 1955	Entirely dry.	Collection of viable spores from the dry bottom mud.

Other members of the Characeae also found growing at the Cooma site are *Chara muelleri* A. Br. and *Nitella gloeostachys* A. Br. A flourishing stand of *Nitella lhotskyi* A. Br. was grown subsequently from spores collected with the bottom mud. In the Western Australian site near Minginew, the species associated with *P. australis* were

TABLE 2.
Comparison between Cooma and Minginew Material and Camden Material of C. australis.

Character.	Cooma Field Material.	Cooma Culture Material.	Minginew Field Material (*fide* Womersley and Ophel).	*C. australis* var. *australis* Camden Field Material.	*C. australis* var. *australis* Camden Culture Material.
Internode diam. (mm.)	1–1·5	0·75–0·85	0·9–1·5	1–1·5	0·85
No. of branchlets (limits)	6–8	6–8	4–7	6 occ. 7	6 occ. 7
No. of segments in branchlets.. ..	3–4	3–4	3–4	3–4	3–4
Length of branchlets (cm.)	0·5–2	0·5–1	1·5–3	1–3 occ. up to 5	1–3 up to 5
Diam. of antheridium (μ)	1000–1250	1000–1250	800–1150	1000–1250	1000–1250
Length of oospore (μ)	650–750	650–750	490–560	725–800	700–800
No. of striae on oospore	5–6	5–6	5–6	5–6	5–6
Height of crown of oogonium (μ) ..	150	150–175	75	125	125
Diam. of crown at base (μ) ..	250–300	275–300	225	250	250
Length of stipulodes (μ)	375	375	Absent	250–300	250–350
Length of bracts (μ)	50–250	50–250	Absent	200–250	200–250
Length of bracteoles (μ)	175–450	175–500	Absent	200–250	200–250

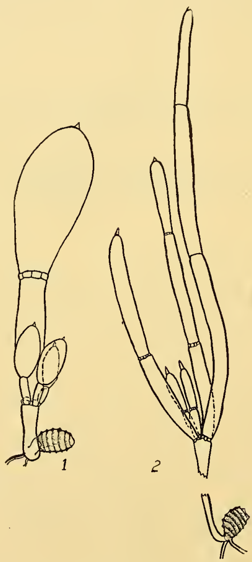
Lamprothamnium macropogon (A. Br.) Ophel and *Nitella gelatinosa* A. Br. This may indicate that the Cooma and Minginew plants have slightly different ecological preferences.

On the other hand, *Chara australis* var. *australis* growing near Parramatta (which may be the type locality) and elsewhere near Sydney, N.S.W., inhabits pools of slowly flowing streams and other permanent bodies of water. In these areas *Chara australis* is often associated with *Nitella cristata* A. Br. and *Chara gymnopitys* A. Br.

Morphology.

General.

Cultures of *Protochara* from Cooma and of *Chara australis* var. *australis* from Camden were set up for potential use in cell physiological studies. The two forms were noted to be very similar in habit. This is shown by the data given in Table 2, in which a comparison of characters generally used in species descriptions is made for *Protochara australis* from Cooma and Minginew and *Chara australis* from Camden.



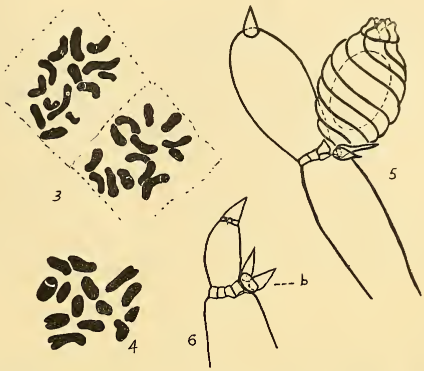
Text-fig. 1. *C. australis* subsp. *estipulodica* (= *Protochara australis*). Camera lucida drawing of young sporeling stage showing inflated protonemal appendage. *Ca.* × 10.

Text-fig. 2. *C. australis* subsp. *australis*. Camera lucida drawing of young sporeling stage showing protonemal appendage. *Ca.* × 10.

Stipulodes, Bracts and Bracteoles.

Occasional stipulodes, bracts and bracteoles were noted during routine examination of the cultures. The preserved field material from Cooma was re-examined carefully, and nearly every strand was found to have one or two stipulodes or bract-cells (Plate x, Figs. 1–3). Furthermore, the female plants from Cooma repeatedly showed 3–4 well-developed bracteoles closely appressed to the lower side of each oogonium so as to be practically invisible until the oogonium was detached (Plate x, Fig. 4; Text-figures 5, 6). No bracteoles were found under the antheridia of male plants, but a bract was often present at nodes bearing antheridia.

Portions comprising some 5–20 nodes each were selected at random from male and female plants of cultured and field material and were examined at a magnification of 40×. Each axial node was scored for the number of branchlets and stipulodes; each



Text-fig. 3. Mitosis, spermatogenous filament, *C. australis* subsp. *estipulodica* (= *Protochara australis*). Camera lucida drawing of metaphase showing 14 chromosomes. *Ca.* ×1750.

Text-fig. 4. Mitosis, spermatogenous filaments, *Chara australis* subsp. *australis*. Camera lucida drawing of metaphase showing 14 chromosomes. *Ca.* ×1750.

Text-fig. 5. *C. australis* subsp. *estipulodica* (= *Protochara australis*) from Cooma, New South Wales. Camera lucida drawing showing bracteoles subtending oogonium. *Ca.* × 20.

Text-fig. 6. *C. australis* subsp. *estipulodica* (= *Protochara australis*) from Cooma, New South Wales. Camera lucida drawing showing bracteoles; oogonium detached at *b*. *Ca.* × 20.

TABLE 3.

Frequency of Stipulodes and Bracts for Protochara australis *from Cooma Pond.*

	Cultivated Plants.		Preserved Field Material.	
	♀	♂	♀	♂
No. of different plants sampled	7	5	Indeterminate	Indeterminate
Total No. of filaments examined	7	14	4	4
Total No. of nodes counted	125	193	39	52
No. of filaments having, per 100 axial nodes:				
0 stipulodes	1	8	1	3
0– 5	0	1	0	1
5–10	1	2	1	0
10–15	2	1	1	0
15–20	3	2	0	0
20+	0	1	1	0
Actual No. of stipulodes present on the number of nodes counted	12 in 125	28 in 193	7 in 39	1 in 52
No. of plants having, per 100 branchlet nodes:				
0 bracts	4	5	1	2
0– 2	1	3	1	1
2– 5	2	1	1	0
5–10	0	2	1	1
10–20	0	2	0	0
20–30	0	2	0	0
30+	0	1	0	0
Actual No. of bracts present on the number of branchlet nodes counted	8 in 602	99 in 1092	12 in 364	19 in 165